STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

LOAD TESTING OF STANDARD LIGHTING AND SIGNAL POLES AND MAST ARMS

March 1, 1958

58-17

MATERIALS & RESEARCH DEPARTMENT

State of California
Department of Public Works
Division of Highways
Materials and Research Department

March 1, 1958

Laboratory Project
Authorization 81-R-6066

Mr. G. M. Webb, Traffic Engineer
Public Works Department
1120 N Street
Sacramento, California

Dear Sir:

Submitted for your consideration is:

A REPORT ON

LOAD TESTING OF STANDARD LIGHTING

AND SIGNAL POLES AND MAST ARMS

Study made by . . . . Structural Materials Section
Under general direction of . . . . J. L. Beaton
Work directed by . . . . L. S. Hannibal
Work supervised by . . . . H. F. Kuhlman and J. E. Barton
Report prepared by . . . . W. E. Faist and V. M. Sayers

Very truly yours,

F. N. Hveem

F. N. Hveem
Materials and Research Engineer

cc: JWTrask
ALElliott
FEBaxter
GLangsner
MHarris
HCMcCarty
GGMcGinness
RRNorton

TABLE OF CONTENTS

LOAD TESTING OF STANDARD LIGHTING AND SIGNAL POLES AND MAST ARMS

I. INTRODUCTION

The purpose of this investigation was to test a group of lighting and signal poles and their mast arms in accordance with a proposed performance type specification (dated 11-9-55). To date, lighting and signal poles have been supplied to contract projects in accordance with the provisions of Section 60, Chapter II, article (d), Standards and Posts, of the California State Division of Highways Standard Specifications of August 1954.

The above proposed specification and a set of preliminary drawings titled "Standard Lighting and Signal Poles" were furnished to the Materials and Research Department on October 26, 1955, by G. M. Webb, Traffic Engineer. Copies of these suggested specifications are included in the Appendix as Exhibit A. The preliminary drawings are on file in the Bridge Department under the title "Light Pole Study, Sheet 1".

In addition to examining the behavior of the lighting and signal poles with respect to the proposed specifications, such additional studies or observations were performed as were deemed essential to improve the scope of the proposed specifications. In this latter instance a series of deflection studies was performed upon the mast arms to determine the most efficient rise and contour pattern, as well as a dependable method of securely guying such arms.

The nomenclature adapted in this report is that which was suggested in the above-mentioned standardization drawing of the lighting and signal poles, wherein the term "pole" is employed in lieu of post, standard, shaft, or mast. "Pole" refers to the complete assembly; however, the adjectives "lighting" or "signal" are used with the word "pole" to indicate the use of the complete assembly. "Mast arm" is employed universally for the extended arm which may hold the luminaires, signs, signal lights, or other fixtures. "Base" refers to the flanged mounting plate on the base of the pole. "Top" refers to the cap or head of the pole. "Footing" refers to the concrete foundation upon which the pole base is mounted.

Exhibit C in the Appendix illustrates these points.

II. SUMMARY

An examination of various lighting and signal poles in reference to the proposed specifications, shows the proposed specifications to be practical but indicates that the several additional features listed below should be considered.

1. A 1% deflection of the pole is visibly apparent. Poles with mast arms loaded at the extremity with 100 pounds of equipment should not show a deflection exceeding 1% of the height.

2. The flange base to the poles should be standardized.

3. The mast arm shoe of all models should be standardized.

4. The contour of the mast arm should be standardized.

5. The location and means of attaching a guy rod fitting to the mast arm should be standardized.

6. Guy rod holes in cross arms should be properly aligned to prevent bending of the mast arm guy rods.

III. TEST PROCEDURE

The following is a listing of light poles and mast arms tested:

LIGHT POLES

Spec. No.	Manufacturer	Type	Height	Remarks
1	Pacific Union Metal	30-M Concrete	30 ft.	Prestressed
2	Pacific Union Metal	30-M Concrete	30 ft.	Prestressed with additional reinforcing steel
3	Weld-rite	35-M-S-Steel	35 ft.	7 ga. wall
4	Weld-rite	30-2M Steel	30 ft.	7 ga. wall
5	Pacific Union Metal	30-M Steel	30 ft.	11 ga. wall
6	Pacific Union Metal	30-M Steel	30 ft.	11 ga. wall

MAST ARMS

Spec. No.	Manufacturer	Length/feet	Type Guy Rod Attachment
7	Pacific Union Metal	18	Welded clip
8	Weld-rite	18	Friction clip
9	Weld-rite	15	Friction clip
10	Pacific Union Metal	12	Welded clip
11	Pacific Union Metal	12	Welded clip

Assembled poles were tested in an upright position as shown in Figure 12(a) to determine load carrying capabilities of both the poles and mast arms, and in a horizontal position, as shown in Figure 12(b) to determine a satisfactory contour and rise of the mast arms.

The foundation footing and anchoring mechanism used in performing the lateral or horizontal load testing of the upright poles was an arrangement specially designed to insure that all loading and deformations would occur in the pole itself. The anchoring bolts employed were as specified in the drawings. The horizontal load was applied to the poles three inches below the top of the pole with the exception that, due to accessory equipment, it was necessary to apply the load to the concrete poles eighteen inches below the top. The horizontal loading mechanism was operated from a steel testing tower having a base integral with the light pole footing. The anchor bolts of both the tower and light pole footing were tied together with #4 reinforcing bars, so that no appreciable movement could occur in the footing anchorage of the light pole under load.

This horizontal load was applied by a hydraulic jack and was measured with an electrical load cell, and the deflections of the pole were observed with a transit.

The vertical loading on the extremities of the mast arm was performed by loading a small platform with a dead weight attached by cable to the end of the arm; the deflections of the mast arm and pole were observed with a transit.

In making these deflection measurements, the transit was located approximately 200 feet from the pole and readings were taken from calibrated scales attached to both the pole and mast arm. Figures 12 and 13 show a test in process.

The vertical loading tests performed on the extremities of the mast arms indicated initially that the deflection of the arm is a function of the contour of this mast arm and the positioning of the guy rod attachment clamp; therefore, additional investigations were conducted by loading the various arms while the pole was mounted in a horizontal position. By employing this procedure, accurate measurements could be made at 2-foot intervals along the length of the mast arm, and the results of various loadings were plotted to illustrate the differences in contours.

In performing this latter investigation, the pole base was rigidly attached to a heavy wide flanged steel "H" beam, and the load was applied between this steel beam and the end of the mast arm and was maintained parallel to the pole. The upper ends of the pole and the mast arm were supported on rollers which permitted normal deflection of the pole as the load was applied (see Figure 12(b)). The loading was effected by means of a jack and measured by a calibrated spring dynamometer. The deflections and contours were measured from a base line set at right angles to the pole at the point of the mast arm's attachment to the pole. Measurements from such a line isolate any effects of movement or deflection occurring within the pole below the point of attachment.

IV. RESULTS AND OBSERVATIONS

A. Poles

Results of horizontal load tests on the poles are listed in Table I and Figure 1.

The proposed specifications, Exhibit A (employing the new nomenclature), are as follows insofar as horizontal load requirements are concerned:

1. "For poles with one mast arm, a horizontal load of 500 pounds applied at the pole top shall not cause a deflection of more than 5 percent of the pole length." (For a 30-foot pole, the allowable deflection would be 1.5 feet; for a 35-foot pole, the allowable deflection would be 1.75 feet).

2. "For poles with two mast arms, a horizontal load of 675 pounds applied at the pole top shall not cause a deflection of more than 5 percent of the pole length."

3. "For poles with three mast arms, a horizontal load of 850 pounds applied at the pole top shall not cause a deflection of more than 5 percent of the pole length."

Of the six poles tested, Specimens 1, 2, and 4 meet the one-mast-arm specification, and Specimens 1 and 2 meet the two-mast-arm specification. Specimens 3, 5, and 6 all deflected more than the specification limit for the one-mast-arm poles. None meets the three-mast-arm specification.

Specimen 1, the prestressed concrete pole, developed cracks at approximately 750 pounds and retained a permanent set of 0.18 feet. In this test the horizontal load was applied 1.5 feet from the pole top. Deflection at the maximum load (980 pounds) was 2.03 feet.

Specimen 2 developed cracks at approximately 500 pounds, and at maximum load cracks were noted at 1-foot intervals for approximately 20 feet up the pole length (see Figure 14(b)). The permanent set was 0.18 feet. The load in this test was applied 1.5 feet from the pole top. Deflection at the maximum load (760 pounds) was 1.73 feet.

There was no apparent spalling on Specimens 1 and 2.

Test Specimen 3 was loaded 1.5 feet from the pole top, and the deflection was 1.89 feet at 500 pounds. The base of this pole is one inch smaller in bolt circle standard

dimension, and the bolt holes are 1/4" larger than the size stated in the specifications.

Test Specimen 4 was loaded at the top of the pole; the deflection was 1.6 feet at 675 pounds. The holes in the base of this pole were 1/4" undersize.

Test Specimens 5 and 6 were loaded at the top of the pole; the deflection was 1.6 feet at 500 pounds.

B. Mast Arms

All mast arms consisted of 2 inch standard galvanized pipe.

The vertical load deflections on the extremities of various mast arms are listed in Table II.

In performing this test, the horizontal deflections of the poles were measured concurrently with the vertical deflections of the mast arms and are listed in Table II.

The proposed specifications for mast arms are as follows:

"A vertical load of 100 pounds applied at the point of the luminaire or signal attachment shall not cause a vertical deflection exceeding 5 percent of the horizontal length of the mast arm." (The allowable deflection for a 12-foot mast arm is 0.60 feet, for a 15-foot arm is 0.75 feet, for an 18-foot mast arm is 0.90 feet, at 100 pound load.)

C. Clamps and Contour

Specimens 8 and 9 were designed to use a non-skid guy rod clamp. Several tests were made while employing such guy rod clamps, and in no case was it possible to load the mast arm to 250 pounds without clamp slippage; slippage occurred in one test at a loading of 100 pounds.

Specimen 9 was modified by welding a guy rod clamp to the arm at approximately two-thirds of the distance from the pole. Tests performed employing the welded clamp show approximately half the deflection measured while employing the non-skid clamp.

Specimen 8 was modified the same as Specimen 9 and tested in comparison with Specimen 7. The deflection at 100 pounds for Specimen 7 was 0.75 feet, and for Specimen 8 was 0.98 feet with the non-skid clamp and 0.90 feet with the welded clamp. The difference in contour of the mast arm appeared to cause the greater deflection in Specimen 8.

The 12-foot mast arms, Specimens 10 and 11, had welded guy rod clamps, and in all tests performed the measured deflections were within the limits of the proposed specifications.

A special investigation was performed to determine a satisfactory contour or rise in the 15- and 18-foot mast arms and position of welded guy rod clamp.

Figure 2 shows the contour and rise of the mast arms received by this department.

Table III shows the differences in deflection of the various poles using as a standardized reference the same mast arm and loading in all cases.

Figures 3 and 4 show the deflection and contour of mast arms 7 and 8 at comparative loads with the guy rod attachment at the two-thirds point. These mast arms are of the same type and pipe size. Specimen 7 deflected 0.9 feet with a 200 pound load, and Specimen 8 deflected 1.4 feet with a 200 pound load. The maximum load that could be applied to Specimen 8 was 210 pounds with a deflection of 3.4 feet while Specimen 7 deflected 1.4 feet at a 300 pound load.

Figures 5 and 6 show the deflection of Specimens 7 and 8 with the guy rods attached at the three-fourths point. Specimen 7 deflected 0.7 feet with a 150 pound load, while Specimen 8 deflected 2.0 feet. The maximum load which could be applied to Specimen 8 was 170 pounds with a deflection of 2.7 feet, while Specimen 7 had a deflection of 1.4 feet at a 300 pound load.

Mast arm Specimen 9 was tested in the same manner with a welded guy rod attachment at the two-thirds point. The resulting deflection and contour are shown in Figure 7.

D. Comments on Prestressed Concrete Poles

The 30-foot prestressed concrete poles weigh approximately 1600 pounds and to prevent cracks at right angles to the axis of the pole should be supported at all times while in a horizontal position. This presents a major problem in transportation and handling. In weight comparison, the 35-foot steel poles weigh approximately 460 pounds.